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1991 INDUSTRY REPORT CARD

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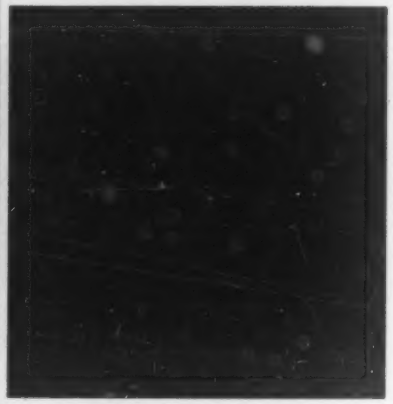

Hard times ahead for the Big Three. See if they made the grade. Page 31.

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Our annual rating of the Big Three.

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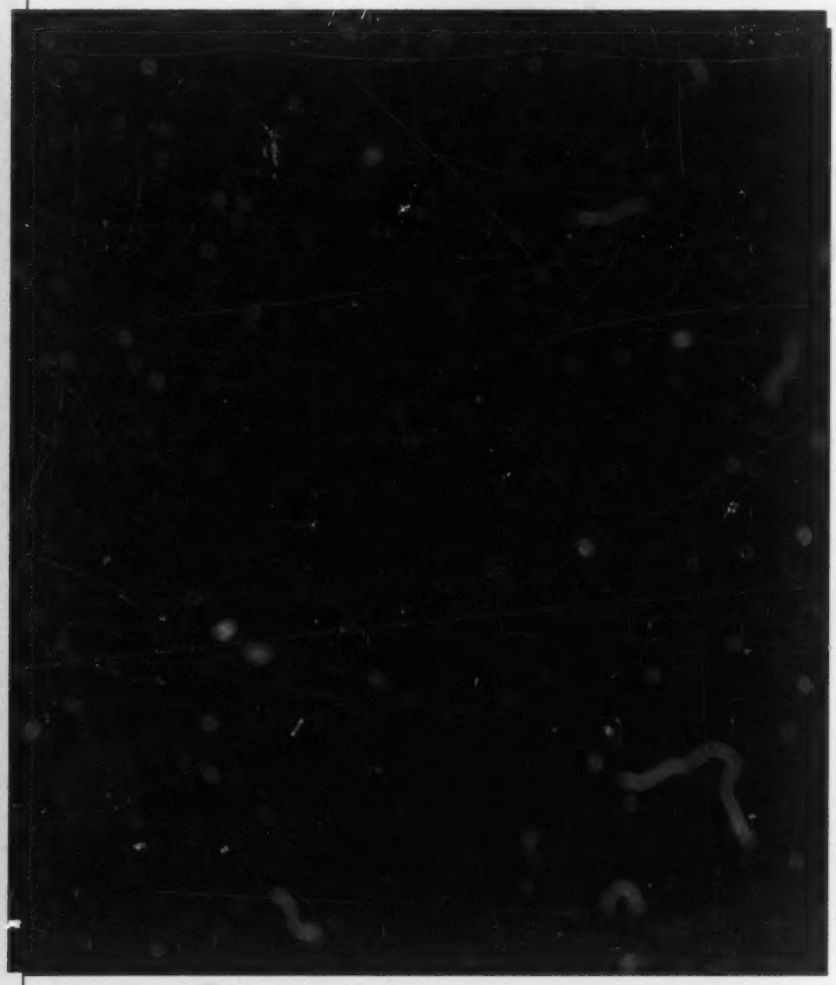
1991 INDUSTRY REPORT CARD

Tough times hit the Motor City.

by JOHN McELROY

Nineteen ninety was a tough time for the US automakers. A slowing economy, the high cost of sales incentives and growing import penetration all took a heavy toll.



Last year the US market fell 4.5% to 13.8 million units, the slowest sales – in recent times – since 1983. In a historical context, this is slightly more than the market reached in 1972, which was then a record year.

Total foreign-brand car and truck sales reached 3.93 million units – not a record sales year for them, though it did represent the highest market share (28.3%) they ever achieved.

The European makers slipped 4.9% to 455,800 units (though Alfa-Romeo, Mercedes-Benz and VW posted modest increases). The Koreans dropped 23% to 229,049 units. And the Japanese came out the big winners.

Japanese automakers saw their total sales in the US market increase 114,000 units to 2,586,100 vehicles. Interestingly, all of this increase came from transplant production, since vehicles exported from Japan to the US fell 10% to 1,525,500 units. Despite the overall Japanese increase Isuzu, Nissan, Subaru and Suzuki all saw their US sales decrease from the year before.

So how badly did the Big Three fare? To help you keep score, *Automotive Industries* once again presents the Industry Report Card. In it, each automaker is graded according to how it performed in six different categories that measure quality, profitability, sales performance, management proficiency, productivity and manufacturing efficiency.

We then compare each company against its past efforts, and sum it up with an overall grade.

(Continued on p. 32)

1991 REPORT CARD

GENERAL MOTORS CORPORATION

Category	1973	1978	1987	1988	1989	1990	Grade
Quality (defects/100)	–	–	176	165	158	149	A+
Profit/Unit	$490	$684	$435	$692	$645	($462)	F
Market Share	51.5%	47.3%	34.7%	34.9%	35.0%	35.5%	A
Return on Sales	6.7%	5.5%	3.5%	4.4%	3.8%	(1.6%)	F
Productivity*	11.4	12.1	11.3	12.9	12.6	12.0	C
Inventory Turns	5.4	6.7	18.0	18.8	20.0	19.3	B-

** = cars/employee/year*

OVERALL GRADE: C

GENERAL MOTORS CORP.

Quality: Our quality rating, which is based on J.D. Power's Initial Quality Survey (IQS), shows that GM reduced its defects per 100 vehicles by 5.7%. In fact, GM has nearly reduced its defects to Ford's level and could sail right past Ford in 1991.

However, almost all of GM's improvement has come from Buick, Oldsmobile and Cadillac – in that order. And Buick is truly the shinning star amongst those three. It now ranks fifth overall amongst all makes sold in the US, having moved past both Honda and Acura in the last year.

Profit/Unit: GM's profit per unit fell 170% from year ago levels. And 100% of this loss came from its US operations.

But GM's overseas operations performed spectacularly. Whereas GM lost over $1200 on every vehicle it built in the US, it earned $1000 on every vehicle it built overseas. This shows how important it will be for GM to try and protect the profitability of its overseas operations – especially those in Europe.

There were three significant reasons that caused GM to lose over $5.7 billion in the US. First, it took a $2 billion write-off for plant closings and other restructurings. That alone accounts for one third of its loss. Second, GM engaged in heavy sales incentives and rebates. Third, as sales fell so did productivity and that caused costs to rise.

Market Share: The good news is that GM picked up half a point of market share in the US. The bad news is that GM's total US sales fell by 171,500 units.

But even though GM's sales were down, they didn't fall off as much as the rest of the market. While the US passenger car market fell nearly 4.9%, GM only fell 3.7%. And while the US truck market fell 3.9%, GM's truck sales only fell 2.6%. That's how it picked up market share.

However, not every GM division was down. Chevrolet increased its passenger car sales compared to 1989, mostly due to the strong performance of the Geo line, especially the Geo Metro.

Return On Sales: By any financial measure, GM performed poorly in 1990. Its Return On Sales fell by more than 140% compared to the year before. Moreover, GM's costs as a percent of total sales are getting worse, not better. Costs and expenses increased by $2.3 billion in 1990. As a result, the new GM management team is taking drastic action.

The company has already announced it will cut 15,000 employees by the end of this year. That could save over $1 billion. It is also putting severe pressure on its suppliers to cut costs and prices by $2 billion a year. And to help free up more cash, the company cut its dividend nearly in half, which should provide management with well over $800 million in cash.

Productivity: GM slipped 4.7% in this category from the year before. But considering that its worldwide sales fell 5.7%, we're actually surprised that its productivity didn't fall off even more. This is why – even though GM has the worst productivity amongst the Big Three – we gave it a C.

Since the company is closing its "idled" plants, and will soon close some other plants, its capacity should come in line with demand. And that could provide GM with some substantial productivity improvements once the market rebounds.

Inventory Turns: GM's inventory turns fell off slightly compared to the year before. On a percentage basis they fell off less than did overall sales. This is a strong indication that the company is doing a better job of managing its manufacturing operations. With less inventory clogging the manufacturing process, quality is bound to improve. Indeed, that is borne out by GM's big improvement in the Quality category.

Will Saturn help GM increase its market share for 1991?

FORD MOTOR COMPANY

Quality: For the last eight years, Ford has been able to claim that it has the best built and designed cars in America, largely thanks to Lincoln's and Mercury's strong showing. But as our Quality rating shows, the company's overall defects per 100 vehicles actually increased 3.2% last year. And now General Motors is starting to breathe down Ford's neck. These figures sug-

(Continued on p. 34)

1991 REPORT CARD

FORD MOTOR COMPANY

Category	1973	1978	1987	1988	1989	1990	Grade
Quality (defects/100)	–	–	156	169	143	147.6	C-
Profit/Unit	$260	$360	$1023	$1014	$663	$53	D
Market Share	29.8%	26.5%	23.1%	23.7%	24.6%	23.8%	C-
Return on Sales	3.9%	3.7%	6.4%	5.7%	3.9%	0.8%	D+
Productivity*	13.7	13.8	18.7	19.9	19.6	16.5	D-
Inventory Turns	5.3	6.5	15.6	17.3	18.0	21.0	A+

** = cars/employee/year*

OVERALL GRADE: C-

gest that unless Ford gets the ball rolling soon, there could be a lot of red faces in Dearborn. So far, Ford's bragging rights to "Who has the best quality?" are heavily based on customer satisfaction at the dealer. That's important. But when independent surveys show your quality is starting to slip at the factory, that should send off alarm bells.

Profit Per Unit: Ford's profit per unit fell a staggering 92% in 1990. But at least the company managed to make money on all the cars and trucks it produced, something GM didn't manage to achieve.

The danger that Ford faces is that its European operations, which had been so profitable throughout most of the 1980s, are now only marginally so. Whereas Ford earned over $2 billion in Europe in 1989, it only earned $116 million there last year. And now the European market is facing the kind of overcapacity that is hurting the profitability of all automakers participating in the US market.

Market Share: Ford lost a lot of the market share momentum it gathered during the 1980s. And fully 30% of the downturn in its 1990 US sales was due to the disastrous launch of the new Escort and Tracer.

But there were some bright spots, too. Explorer went to the head of the sport utility class as sales jumped a whopping 66.7%. Sales at the Lincoln division rose a robust 15.6%, largely due to the overwhelming success of the Town Car. The Crown Victoria was rock solid. And despite the slow start, by year end the new Escort and Tracer were selling strongly. Other than that though, sales of every other car and truck in Ford's line-up went down.

Return On Sales: Financial results were a big disappointment for Ford in 1990. For every dollar that it took in at the cash register, it was only able to keep $^{8}/_{10}$ of a penny after it paid for all its expenses. And this came about even though Ford's financial services turned in a record performance, with $761 million in profits. As a result of the fall-off in profits, Ford eliminated all executive bonuses and did not make any profit sharing payments to its UAW employees for the first time since its profit sharing program was initiated.

Ford's Explorer proves that a great product can sell well, even in a down market.

Not surprisingly, Ford recently announced a worldwide cost cutting program to eliminate $3 billion by the end of 1991. Many analysts predict Ford will also cut its dividend, something that may have already happened by the time you read this.

Productivity: As sales fell faster than Ford (or anyone for that matter) could adjust to the fall-off, productivity suffered. This drop-off had an adverse impact on profitability, as is borne out in our Profit Per Unit category. Specifically, the company's productivity fell 15.8% from year-ago levels. This worsening of its productivity was partly due to the drop in sales, but Ford also increased its worldwide automotive employment level by more than 28,000 employees. Even so, it still managed to remain the most efficient of the US automakers.

Inventory Turns: Despite the drop-off in productivity and quality, Ford was able to dramatically improve its inventory turns, which are an indication of how well a company manages its assembly and production plants from a processing standpoint. Inventory turns improved 16.6% from year ago levels, which is all the more amazing, given all the negatives and uncertainties in the market place which the manufacturing people had to battle against.

CHRYSLER CORPORATION

Quality: After making a tremendous improvement in quality last year's report card, Chrysler slipped slightly in 1990. Though it didn't slip as much as Ford did, that's not much consolation when you're third in a race of three. Compared to all the makes competing in the quality race, Chrysler's divisions are grouped at the back of the pack. And whereas it's the luxury divisions that get high quality ratings at GM and Ford, the opposite is true at Chrysler. Plymouth leads the way followed by Dodge, Eagle and Chrysler. The

(Continued on p. 36)

1991 REPORT CARD

CHRYSLER CORPORATION

Category	1973	1978	1987	1988	1989	1990	Grade
Quality (defects/100)	–	–	178	202	169	172.5	D
Profit/Unit	$127	($129)	$853	$649	$249	$209	C
Market Share	15.6%	11.2%	12.3%	13.9%	13.7%	12.2%	D
Return on Sales	2.1%	(1.5%)	4.5%	3.0%	1.0%	0.2%	D+
Productivity*	13.0	13.1	16.2	18.0	19.5	15.7	D-
Inventory Turns	5.6	6.3	16.8	21.6	26.3	22.5	C-

** = cars/employee/year*

OVERALL GRADE: D

most disconcerting part of Chrysler's quality performance, however, is that it is up and down, year to year. This lack of consistency may be partly explained away as "noise" in the measuring methods. But the fact that Chrysler is going through this kind of roller coaster quality performance doesn't look good. Quality is an area where one expects consistency – and constant improvement.

Profit Per Unit: Chrysler may have slipped in the profitability area, but compared to the folks in Dearborn and Detroit, the ChryCo financial people look like rocket scientists. One area in which Chrysler greatly outperformed its crosstown rivals was with cost cutting. Whereas automotive costs increased $3.2 billion at Ford and $2.3 billion at GM, Chrysler drastically cut its costs by $3.2 billion. That kind of cost cutting went a long way to offset the $4 billion drop in sales that the company suffered. And it shows heads-up thinking on the part of Chrysler's management to cut spending so deeply and so quickly. Ford and GM are only now beginning to follow suit.

Market Share: Chrysler lost so much market share so fast in 1990 that it raises serious concerns about the company's future. It certainly risks losing being ranked as one of the Big Three. Chrysler's car sales fell three times as much as the total market did. Indeed, in passenger cars Honda came within 6000 units of outselling Chrysler. And unlike last year, Dodge trucks and Jeeps didn't help to offset some of the company's sales slippage in passenger cars. In fact, Chrysler's truck sales fell nearly four times as much as the total truck market did.

Return On Sales: No, Chrysler didn't do too well financially in 1990. Its return on sales fell 80% from year ago levels. But that doesn't tell the whole story. In 1989 the profit figures were bolstered by the one-time sale of 75 million shares of Mitsubishi Motors, which improved the bottom line by $309 million. If this is taken into account, then Chrysler's management actually did a better job of managing the company in this category in 1990 compared to the year before. And that's why we weren't as harsh in our grading as you might otherwise expect. Not surprisingly, this small profit margin and the current cash crunch forced Chrysler to cut its dividend in half, which it just announced last month. This move should save the company about $130 million in cold cash a year.

Productivity: After making such solid gains in productivity in the last four years, Chrysler dropped off seriously in this area. And the weak US market doesn't explain all of the downfall. Strangely, despite the company's tremendous sales slowdown, and the closing of the Jefferson Avenue and St. Louis assembly plants, Chrysler's total automotive employment actually increased by nearly 4000 people in 1990. That's not much, but it sure isn't the kind of trendline one would expect to see – especially when GM was able to reduce its worldwide automotive employment by 13,000 people.

Inventory Turns: This is another area where Chrysler fell off, after having made impressive gains recently. Inventory turns fell 14.4% compared to last year, showing how difficult it is to balance production schedules when the market is in a steep and unpredictable slide. Even so, amongst the Big Three, Chrysler is still best-in-class, and that had a positive effect on our grading. AJ

Will A604 transmission problems and increasingly tough competition put a serious dent in Chrysler's Number One money maker?

PRODUCTIVITY COMPARISON

Who has the best assembly plants in the North American auto industry?

by JOHN McELROY

Last year, Harbour and Associates published The Harbour Report, *a competitive assessment of how the North American automotive industry performed during the 1980s. The following charts from that report (with selected plants updated for 1991) compare the productivity of the car and truck assembly plants operating in the United States and Canada.*

A productivity comparison of assembly plants shows that the Ford Motor Company and the Japanese transplants have—by far and away—the most efficient operations in North America.

When comparing the productivity for passenger cars, Ford is close on the heels of the transplants, trailing by only 2.7%. But Chrysler lags by a significant 28.7%, and GM is an astounding 62.3% less efficient.

On average the Japanese transplants in North America need only 3.27 workers per car per day, though this includes extra operations which are explained below. Ford needs only 3.36 workers per car per day in passenger car assembly, compared to 4.21 at Chrysler and 5.31 at GM.

The **most efficient passenger car assembly plant** in North America is the CAMI operation in Ingersol, Ontario in Canada. The plant is run by executives from Suzuki and builds the Geo Prizm/Suzuki Firefly and the Geo Tracker/Suzuki Sidekick.

The **most efficient Big Three car assembly plant** is Ford's Atlanta plant, which makes the Taurus and Sable. And Ford has several other plants that are very close to Atlanta's world class level of efficiency.

The **most efficient truck assembly plant** in North America is Ford's Kansas City plant which makes F-series pick-ups and the Tempo compact car.

The **most efficient transplant truck plant** is Nissan's Smyrna facility that makes compact pick-ups and Sentras.

It should be pointed out that these productivity rankings do not reflect the quality of the vehicles made at these plants. For example, according to J.D. Power's Initial Quality Survey, General Motor's Buick City plant, which ranks 21st on the productivity list, actually assembles the most defect-free car made in America, which is the Buick LeSabre. Also, GM's Saturn plant is not on this list because at press time it hadn't reached line speed, so productivity numbers were impossible to come by.

Some people will be surprised to see so many Ford plants rated ahead of the transplants. This is partly because the transplants perform extra operations, such as stamping and plastic molding, that are typically not found in Big Three assembly plants. However, new or re-tooled Big Three assembly plants, such as Ford's Wayne plant and GM's Fairfax plant and Saturn, increasingly incorporate these kinds of operations on-site.

The overall conclusion one can draw from these car and truck productivity comparisons is that the best plants in North America are very competitive with the best plants in Japan. They're world class. But the worst plants—unless they make significant improvements—may not survive the overcapacity crunch in North America. Some of them are likely to risk extinction by the end of the century.

How We Measured Productivity

One of the easiest ways to start an argument in the auto industry is to talk about productivity. Every expert has an opinion, and they all use different methods to measure it.

The only way to avoid an argument on productivity is to agree on what you're going to measure and *how* you're going to measure it. The problem is that two of the most common methods that are used, cars/employee/year and man-hours-of-assembly, have flaws.

The problem with the cars/employee/year formula is that it only works well when production is slowly increasing. Since it doesn't take overtime or downtime into account, it overstates changes in productivity when

volume fluctuates significantly.

The problem with the man-hours-of-assembly formula is that hours of overtime and absenteeism rates must be used in the calculations. As long as you can get those figures, you'll be able to calculate the productivity rate. Unfortunately, the automakers don't make this information public. And while it's possible to estimate these figures, guessing is a haphazard way to make accurate comparisons.

The best way to calculate productivity, without overstating any changes in production, and without having to guesstimate, is to use workers per unit of output, or as is shown in the accompanying charts, workers per car and workers per truck. This calculation takes the annual output at a plant and divides that by the number of workers who work there. The number of work days at the plant is then divided by the number of cars or trucks each worker made during the year. This calculation does not take absenteeism into account and it does not recognize overtime. Nonetheless, it represents a consistent and accurate system that is particularly effective for analyzing productivity over a lengthy period of time.

Continued on p.54

RANKING THE CAR ASSEMBLY PLANTS

Company	Plant	Product	Workers Per Car	% Over Base	Comments
1. CAMI	Ingersol	Metro/Tracker/Sidekick	2.40 A	Base	The Best in the West
2. Ford	Atlanta	Taurus/Sable	2.66	10.8%	Best Of Big Three
3. Ford	Chicago	Taurus/Sable	2.68	11.6%	Look Out Atlanta!
4. Ford	Kansas City	Tempo/FS P-Up	2.68	11.6%	Large Volume Helps
5. Ford	Oakville	Tempo/Topaz	2.82	17.5%	Good Show, Eh?
6. Honda	Alliston	Civic	2.88 A	20.0%	Uses Marysville Parts
7. Honda	E. Liberty	Civic	2.89 A	20.4%	Same As Above
8. Nissan	Smyrna	Sentra/P-Up	2.98 A	24.1%	Solid Showing
9. Diamond Star	Normal	Eclpise/Laser	3.00 A	25.0%	Successful JV
10. Chrysler	Sterling Heights	Sundance/Shadow	3.18	58.7%	Chrysler's Best
11. Ford	Dearborn	Mustang	3.24	35.0%	Old, Old Car
12. SIA	Lafayette	Legacy/P-Up	3.32 A	38.0%	Needs Volume
13. Toyota	Georgetown	Camry	3.54 A	47.5%	Not A UAW Plant
14. Mazda	Flat Rock	626/MX-6/Probe	3.56 A	48.3%	A UAW Plant
15. Honda	Marysville	Civic/Accord	3.61 A,C	50.4%	Extra Operations
16. Ford	Wayne	Escort	3.61 A	50.4%	Start-Up Phase
17. NUMMI	Fremont	Prizm/Corolla	3.73 A	55.4%	A Toyota Operation
18. Chrysler	Belvidere	Dynasty/N.Y./Imp.	3.74	81.2%	Mid-Size Luxury
19. Ford	Lorain	T-Bird/Cougar	3.76	56.6%	Should Be Better
20. Ford	St. Thomas	Crown Vic/Marquis	3.93	63.7%	New Car Will Help
21. General Motors	Linden	Corsica/Beretta	3.94	64.1%	GM's Best
22. Chrysler	Newark	Acclaim/Spirit	3.95	81.6%	Go Catch Sterling
23. General Motors	Buick City	LeSabre/88	4.04	68.3%	High Quality Plant
24. Toyota	Cambridge	Corolla	4.05 A	68.7%	Last Place Transplant
25. General Motors	Wilmington	Corsica/Beretta	4.31	79.5%	Way Behind Linden
26. Chrysler	St. Louis	LeBaron/Daytona	4.36	80.4%	Soon To Close
27. General Motors	Lansing	'N' Cars	4.39	82.5%	Handles Exports, Too
28. Ford	Wixom	Lincoln	4.86	102.5%	Three Platforms
29. General Motors	Oshawa	'W' Cars	4.87	102.9%	Not So New Mid-size
30. General Motors	Lordstown	'J' Car	4.96	106.6%	Old Product
31. General Motors	Oklahoma City	'A' Cars	5.19	116.2%	Old Mid-Size
32. General Motors	Fairfax	Grand Prix	5.25	118.7%	GM's Newest Plant
33. General Motors	Arlington	'B' Cars	5.28	120.0%	Old Brougham
34. General Motors	Wentzville	Park Avenue	5.42	125.8%	Big Cars/Big Manning
35. General Motors	Doraville	Cutlass	5.50	129.1%	One Car Plant
36. General Motors	St. Therese	Ciera	5.51	129.5%	Old Mid-Size
37. General Motors	Van Nuys	Camaro	5.62	134.1%	High Freight Too
38. General Motors	Orion	DeVille, 98	5.94	147.5%	Same As Wentzville
39. General Motors	Ypsilanti	'B' Cars	6.91	187.9%	Should Equal St. Thomas
40. General Motors	Hamtramck	'E'/'K' Cars	7.85	227.0%	Only One Shift

Excludes: Reatta/Corvette
(A) With Body Stamping, Stamping Assembly, or Major Injection Molded Plastics; Without Seats
(B) With Light Duty Trucks
(C) Includes Supplier Quality, Product Engineering Staffs
(D) With Medium Duty Trucks

Continued from p. 53

RANKING THE TRUCK ASSEMBLY PLANTS

Company	Plant	Product	Workers Per Car	% Over Base	Comments
1. Ford	Kansas City	F-Series/Tempo	2.68	Base	Best In The West
2. Ford	Norfolk	F-Series	2.72	1.4%	A Close Second
3. Ford	Louisville	Ranger/Explorer	2.81	5.2%	New Product Added
4. Nissan	Smyrna	P-Up/Sentra	2.98 A	11.1%	Best Transplant
5. Ford	Ontario Truck	F-Series	3.02	12.6%	Best In Canada
6. Ford	Twin Cities	Ranger	3.05	13.8%	Compact Truck
7. Ford	Michigan Truck	F-Series	3.15	17.5%	Full-Size Truck
8. General Motors	Fort Wayne	C/K Truck	3.23	20.5%	GM's Best
9. SIA	Lafayette	P-Up/Legacy	3.32 A	23.8%	Needs Volume
10. General Motors	Moraine	S10	3.35	25.0%	Compact Truck
11. Ford	St. Louis	Aerostar	3.36 B	25.3%	Best Minivan
12. General Motors	Shrevesport	S10, Blazer, S15	3.39	26.4%	Look at Louisville
13. General Motors	Pontiac East	C/K Truck	3.54	32.0%	Newest Truck Plant
14. General Motors	Oshawa	C/K Truck	4.04	50.7%	Next Best In Canada
15. Ford	Lorain	Big Van	4.10 A	52.9%	Best Large Van
16. Chrysler	Windsor	Caravan/Voyager	4.39	63.8%	Best From Chrysler
17. Chrysler	Warren	Dakota/P-Up	4.63	72.7%	Compact Truck
18. General Motors	Baltimore	Astro/Safari	4.92	83.5%	Way Behind Ford
19. General Motors	Janesville	Med. Truck	4.94	84.3%	No More J-Car
20. General Motors	Pontiac West	S10, Blazer, S15	5.00	86.5%	To Be Closed
21. General Motors	Lordstown	Big Van	5.17	92.9%	To Be Closed
22. Chrysler	Pillette	Big Van	5.17	92.9%	Not Any Better
23. Chrysler	Missouri	Caravan/Voyager	5.32	98.5%	Extended Van
24. General Motors	Flint	Suburban/Blazer	6.17	130.0%	To Be Closed
25. Chrysler	Toledo	Jeep	6.87	156.3%	Includes Stamping
26. General Motors	Scarborough	Big Van	7.15	178.0%	Closing Soon?

(A) With Cars (B) With Light Duty Trucks

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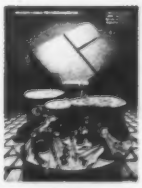

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THE WORLD'S FASTEST GROWING MARKET

The Pacific Rim nations of Southeast Asia are consistently scoring double-digit growth. Japan sets its sights on Thailand.

by JOSEPH M. CALLAHAN

While Western automakers have focused on new business opportunities in Eastern Europe, Japanese automakers are aiming to make Southeast Asia the world's low-cost location for assembling vehicles and making parts.

The Honda Motor Co. expects Thailand to be its third largest production base next to Japan and the US, according to Dr. Kosol Surakomol, managing director of Bangchan General Assembly Co., which assembles CKD (complete knock-down) kits from Honda, Opel, Isuzu and others. And he says Honda is also considering Thailand as a major base of exports throughout Southeast Asia—a stupendous projection for a country that assembled just 82,000 vehicles in 1985.

Toyota, Nissan, Mitsubishi, Mazda and Isuzu see Southeast Asia as a key link in their global strategies for the 1990s, writes Michael Dunne in his recently published study, *The State of the Auto Industry in Thailand*.

Besides its low costs, the Pacific Rim has another major attraction. The region is home to a third of a billion people, and that's not counting China and Japan (see chart).

Thailand will become one of the world's largest automotive manufacturing centers by 1995, industry analysts predict, exporting components, systems and finished vehicles in significant volume to markets in Europe, Asia and North America. The country already has one of the hottest economies in the world, racking up increases in GNP of 10.9% in 1988, 10.5% in 1989 and 9.9% in 1990.

Already the Japanese and some European firms have announced plans to almost triple their automotive assembly capacity by 1995, boosting it from 283,500 units now to 746,000 units in four years. The expanding firms include Bangchan General Assembly, Isuzu Motors (of Thailand), MMC Sitipol (Mitsubishi), Siam Motors (Nissan), Sukosol and Mazda Motor, Tai Hino, Thai-Swedish Assembly (Volvo, Renault), Thornburi Auto Assembly (Daimler-Benz), Toyota Motor Thailand and Yontrakit Motor (BMW, Peugeot and Citroën).

Conspicuously absent from the list of foreign automakers expanding into the region are the Americans. Except for a limited number of Holden and Opel cars, GM and Ford have pulled out of the operations they had in the region in the 1970s. Both companies now have teams again studying the resumption of vehicle assembly in Thailand.

But their start-up will be difficult. Thailand has very stringent local-content rules: 62% for pick-up trucks (Thailand's national vehicle), 54% for cars and 45% for heavy-duty trucks.

Moreover, just as the Japanese automakers have managed to seal off their home market to foreign suppliers, they appear to be doing the same in Southeast Asia. The Japanese, who now sell 95% of the vehicles in Thailand, have them all arranged in 'clubs,' in which they do business with just one Japanese firm and nobody else. AI

PACIFIC RIM MOTOR VEHICLE PRODUCTION*

Country	Population[1]	Car Production	Commercial Vehicles Production	Total Vehicle Production	% of S.E. Asian Production
S. Korea	43,100,000	871,888	257,572	1,129,970	7.3
Taiwan	20,000,000	256,437	77,404	333,841	2.1
Thailand	55,600,000	58,761	154,787	213,548	1.4
Indonesia	184,600,000	31,906	146,886	178,792	1.1
Malaysia	17,400,000	79,962	43,278	123,240	0.8
Hong Kong	5,700,000	31,947	18,306	50,253	0.3
Singapore	2,700,000	32,692	6,241	39,933	0.2
TOTALS	329,000,000	1,363,593	704,474	1,769,577	99.9

** 1989 Figures from MVMTA, MVMA (US), The Economist Intelligence Unit (Great Britain) and others.*
[1] United Nations 1989 population estimates.

INDUSTRY OUTLOOK

by JOHN McELROY

When it comes to predicting what will happen in the North American auto industry, the Big Three and the transplants, the captive suppliers and the independents, all have different opinions.

Automakers and suppliers operating in North America know they have their work cut out for them. But they don't exactly see eye-to-eye on which problems loom largest. Nor do they agree on the best ways to tackle these problems. And the divergence of opinion is quite significant between the Big Three and the Japanese transplants, as well as between captive and independent suppliers.

These differences were recently brought to light by a major study of the US automotive market, *The New Automotive Frontier: Effective Implementation*. The study is based on answers to questionnaires from nearly 1000 executives in the auto industry, including 170 participants from the Big Three and Japanese transplants, 259 participants from captive suppliers, and 544 participants from independent suppliers including Japanese-owned companies with facilities in the United States. The study was conducted by Arthur Andersen and Company under the direction of Peter C. Van Hull and Shari T. Guilfoile.

The report gets its name from the fact that many people in the auto industry believe their companies have good plans and strategies to improve their competitiveness, but they don't think their companies are effective at implementing them.

The Arthur Andersen firm is well known for the six Delphi studies of the auto industry it has conducted since 1978. But for *The New Automotive Frontier*, the company dropped the Delphi methodology. Instead of asking participants where they thought the industry as a whole is headed, they asked them to comment specifically about their own companies.

Source: Arthur Andersen & Co. Figures 1 & 2

What do you believe are the primary product and process technology drivers for your products between now and 1995?

Product Technology Drivers

	Vehicle Manufacturers	Suppliers
Variable cost reduction	22%	28%
Investment cost reduction	11	7
Improve product features and functionality	**25**	**39**
Improve product performance	19	26
Quality and durability improvement	**39**	**36**
Satisfy government regulations	**25**	11
Weight and mass reduction	12	19
Speed to market	17	9
Market flexibility and responsiveness	13	10
Ease of manufacturing and assembly	18	15

Process Technology Drivers

	Vehicle Manufacturers	Suppliers
Variable cost reduction	38%	**58%**
Investment cost reduction	32	31
Improve product features and functionality	1	5
Improve product performance	6	6
Quality and durability improvement	**40**	**36**
Satisfy government regulations	5	4
Weight and mass reduction	-	4
Speed to market	10	6
Market flexibility and responsiveness	26	15
Ease of manufacturing and assembly	**41**	35

And whereas the Delphi method would have aggregated these answers to provide an "average" or overall viewpoint, the new method allows the participants' responses to be broken out by where they're from and what they do.

For example, any of the questions

can be grouped by answers from US vehicle manufacturers, Japanese vehicle manufacturers, captive suppliers, US independent suppliers and Japanese independent suppliers. Even more, each of these categories can be further broken down by the area of expertise the respondants represent including: body exterior; body interior; powertrain; chassis, steering, suspension, and brakes; electrical and electronics.

By being able to break out the answers to this level of detail, the study allows a company to accurately establish competitive benchmarks as to how it views the industry vis-à-vis its competitors. Arthur Andersen is making the full benchmark study available for $3000. A more concise overview is offered for $300 and is summarised below.

Major Findings

The data contained in the *The New Automotive Frontier* is too extensive to thoroughly cover here. Nonetheless, there are four significant areas that help set the overall tone for the report. The first deals with the most important market forces facing the auto industry in the next five years. The next two areas deal with those items most critical to driving improvements in product and process technology. Finally, the report also delves into the roadblocks that are preventing the effective introduction of new technology. Each of these areas provides plenty of data to stimulate interest and analysis.

Not surprisingly, automakers and suppliers alike feel that improvements in quality and cost reduction will be the most important issue facing them in the next five years (see Figure 3). But while automakers are sharply focused on reducing their product life cycles and leadtime, suppliers have other more pressing items on their agenda.

Suppliers indicate they are more concerned with globalization, recognizing that the biggest growth in the industry will likely take place outside of the North American market. GM and Ford and the Japanese automakers already have extensive international operations, and US-based

Most important market force issues facing your organization during the next five years.

	Vehicle Manufacturers	Suppliers
Niche marketing and product proliferation	12%	17%
Industry globalization	25	**38**
Shorter product life cycles and development leadtimes	**52**	**34**
Continual technology innovation	15	33
Vehicle systems trends	6	16
Increasing consumer/customer expectations	30	31
Slower market growth	19	19
Larger number of competitors	25	14
Excess production capacity	**38**	19
Pressure for continuous quality and cost improvement	**78**	**76**

Figure 3

Source: Arthur Andersen & Co.

suppliers are now recognizing they too must have overseas facilities if they are to retain their client base.

Additionally, these suppliers place a greater premium on continuous technological innovation than do the automakers. This suggests that suppliers see proprietary technology as a key to capturing new business and as a way to command higher profit margins. Interestingly, while the vehicle manufacturers are worried about overcapacity in the market, suppliers seem to feel that they've got their capacity pretty much in line with demand.

When it comes to ranking which issues are most important in improving product technology, the automakers bore in on quality and and durability (see Figure 1). Suppliers are also concerned with this, but they rank improvements in product features and functionality as their number one product concern. This may mean that suppliers are now more focused on designing products that meet their clients' and customers' needs and expectations. And dovetailing with this focus on better design is the suppliers' concern to reduce variable costs, an issue they rate higher than satisfying government regulations.

Recognizing that it is ever more difficult to separate design from manufacturing, reducing variable costs is also the suppliers' top concern in terms of improving process technology (see Figure 2). The automakers, on the other hand, rate ease of manufacturing and assembly as their top process priority. This seems to tie in with the industry's recognition that it must be ready and able to meet changes in market demand, especially as this relates to low-volume and niche vehicles.

Interestingly, both automakers and suppliers blame their respective managements for the ineffective or inconsistent introduction of new technology (see Figure 4). Both rate short-term management focus as the most significant problem in this area, while the automakers are equally critical of unclear management direction and priorities. Suppliers also say that their customers, the automakers, don't clearly communicate what they need or want, which ties in with the unclear management direction that automakers say they suffer from. It's also clear that as suppliers take on more design and engineering responsibilities, they're concerned that they don't have the internal competence or capabilities to get the job done—an acute problem since suppliers believe that development leadtimes will be more compressed (see Figure 5).

Reasons for Ineffectiveness and/or Inconsistency

	Vehicle Manufacturers	Suppliers
Poor customer/supplier relationships (lack of communication, early sourcing, etc.)	29%	17%
Exploding technology has dissipated resources	11	15
Unclear management direction and priorities	**53**	**34**
Lack of understanding of consumer/customer needs and wants	13	27
Inadequate financial resources	15	16
Supply community lacks expertise	2	3
Lack of internal core competencies/ capabilities	25	27
Short-term management focus	**53**	**47**
Aversion to risk	28	14

Figure 4 Source: Arthur Andersen & Co.

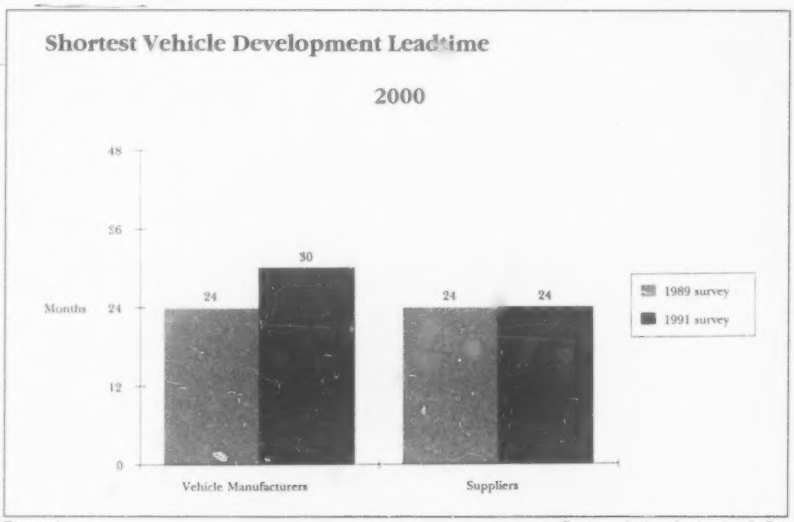

Figure 5 Source: Arthur Andersen & Co.

How To Order

Additional benchmarking topics covered in *The New Automotive Frontier: Effective Implementation* include product life cycles, development leadtime reduction, investment targets, potential unit cost reductions, target costing, translation of product concepts into specifications, quality gaps between US and Japanese owned facilities, captive vs. independent supplier sourcing, the status of customer/supplier relationships and much more.

For a brochure, or to place an order, contact: Donna Borrelli, *Automotive Industries*, One Chilton Way, Radnor, PA 19089. Tel: (215) 964-4245. Fax: (215) 964-4981. AI

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CHILTON'S
AUTOMOTIVE INDUSTRIES
MAY 1991
THE PEOPLE — THE PRODUCT — THE PROCESS

A postwar oil glut

CAFE: 40 mpg

Why the industry can't meet it.

What the industry can do.

FOR CARMAKERS, THE BAD NEWS IN THE AIR

The auto industry, with a big push from its friends in the Bush Administration, has managed to sidetrack legislation that would have required a massive increase in the fuel efficiency of cars. But the victory offers Detroit nothing more than a temporary reprieve.

The auto makers' woes are mounting fast. Soaring oil prices and a sagging economy threaten to torpedo already shaky car sales. Congress is about to enact a revised Clean Air [Act] requiring tough new emissions standards and large-scale production of cars that can burn alternative fuels. And the [energy] efficiency bill, which has strong backing in both Houses, will [be passed] this year.

CAFE standards won't help

achieve an [average] ... for their car fleets. ... Lately, ... proposed increasing the CAFE ... continues to be debated. Below we present sides of this debate. Arguing in favor of standards is Clarence Ditlow, head Center for Auto Safety. The Secretary Department of Transportation, Samuel K ... cites problems with increasing the CA ... addition, we present evidence that gests that current CAFE standards have the cars we drive less safely. —Ed.

ELECTRIC CARS IN CALIFORNIA?

It hasn't been a particularly good year for auto companies. Sales are off, and Congress is considering new standards for fuel economy. Now, California is about to push through the most stringent auto-emissions regulations in the country. The rules are so tough [that] ... auto companies ... improved fuel ...

BRYAN: PUSHING NEW FUEL-ECONOMY LIMITS

...se in CAFE

...kinner

... by Senator Bryan and oth... substantially increase the ...er. With Congress rush... ...r cars and light trucks ... enough to kill the measure ... lobbyists are already ...ates. The bill would

More CAFE.

By Clarence M. Dit...

The motor vehicle ... mandated by Congress ... nificant energy conser... country. The question ... should be increased b... ...er for Auto Safety ha...

Deba... on fu... econ... flar...

■ Issue... will ... incr...

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WAS...

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Cheap oil for years to come.

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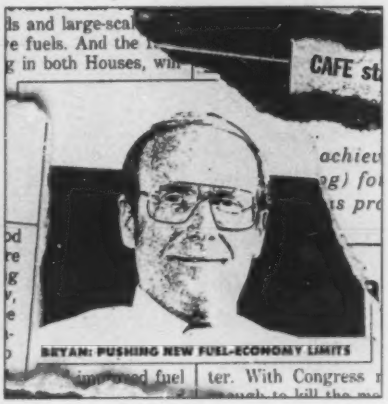

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Volume 171, No. 5 May 1991

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40-MPG CAFE

Everyone agrees the US must reduce its dependence on oil. Now the issue will be decided in Congress. Once again the auto industry has missed an opportunity.

by LINDSAY BROOKE, GERRY KOBE, JOHN McELROY and CHRISTOPHER A. SAWYER

Senator Richard Bryan has become a household name in the auto industry. The Nevada Democrat adamantly believes the auto industry can improve the fuel efficiency of its vehicles. And he's right. The industry believes it can improve fuel efficiency, too. But an argument – a big argument – arises when you ask by *how much* fuel economy can be improved.

Senator Bryan says it's possible to achieve a 20% improvement in Corporate Average Fuel Economy (CAFE) by 1996, and a 40% improvement by 2001. Automakers respond by saying such a law is either impossible to achieve, or not worth implementing. Honda, for example, claims it could make a 5% improvement. General Motors points out it already sells Geo Metros that achieve 50 mpg, but customers are not exactly trading in their Buicks to buy them.

"Raising vehicle fuel efficiency standards is a very indirect and inefficient flawed way of trying to reduce oil imports through fuel conservation," said Thomas Hanna, president and CEO of the Motor Vehicle Manufacturers Association, in a March testimony before the House Subcommittee on Energy and Power.

At this juncture who's right is a moot point. One way or another the issue is going to be settled by the political process, because even if the Bryan bill is shot down in flames, there are six other CAFE bills waiting in the wings. Reacting to the Persian Gulf war and the Valdez oil spill, Congressional Democrats perceive there is a national mandate to reduce the country's dependence on oil – especially foreign oil – and want to use legislative muscle to make it happen. Conversely, Republicans generally prefer to see the marketplace regulate any kind of improvement.

So the fight has now boiled down to who is the most persuasive. And right off the bat the auto industry has two strikes against it.

"The auto industry has a history of denying anything is possible, then proving itself wrong by going out and doing it," says Steve Plotkin, a senior associate at the Office of Technology Assessment (OTA).

Moreover, Senator Bryan has amassed a persuasive list of facts. His call for massive CAFE improvements is based on technical reports and testimony to Congress from the OTA, EPA, DOE and national laboratories at Oak Ridge and Berkeley. These reports indicate that a 40 mpg CAFE is achievable by 2000.

True, say some in the auto industry. But even if it is 'achievable' that doesn't mean it's 'affordable.' And even the most ardent hold-their-feet-to-the-fire regulators concede that big improvements in fuel economy won't come cheaply. That's a deeply troubling fact to the auto industry.

In 1990, the typical new car cost $16,500 including nearly $2500 worth of government-mandated fuel economy, emission and safety equipment. Inflation alone will likely push that sticker price to $25,000 in 10 years, and automakers are concerned that family incomes won't keep pace. What good is a fuel-efficient family car that families can't afford, ask auto industry executives? MVMA president Hanna adds that a resulting drop in sales could cause the loss of over 150,000 US automotive industry jobs.

But others say that consumers will recoup that added expense when the fuel savings are spread over four or five years. Besides, say those involved in the political process, Congress knows it is forcing the auto industry to do the impossible, just as the auto industry knows it can do more than it admits to. That's how the game is played.

"When you're in the bargaining process it pays to hold to your position until the last possible moment," says Steve Plotkin at the OTA. "There's no incentive for anyone in the industry to say it can be done; otherwise this feeds the drive for big fuel economy improvements."

He adds that the authors of the technical reports on which the Bryan bill is based acknowledge that a 20% or 40% CAFE improvement would be difficult to achieve without a radical and total redesign of the fleet. Since the 1996 models are already on the drawing board, and many models are already planned out through 1998, it would be virtually impossible for automakers to recoup their investment on these cars if faced with a stringent CAFE bill.

A more realistic CAFE goal by 1996, says Plotkin, is a 30 mpg CAFE. "The national CAFE is already at about 28 mpg and it'll get to 29 mpg on its own," he notes, "so we're saying you can squeeze 1 mpg more by 1996." A 38 mpg CAFE would be feasible by 2001, he says, provided automakers are given generous CAFE credits for flex-fuel cars – cars that can run on a combination of gasoline and methanol or other alternate fuels. Currently such credits are capped to 1 mpg, but the Bush Administration is asking for them to be uncapped.

"A lot of the people who have heard us [the OTA] know we're talking about numbers that are lower [than those in the Bryan bill]. I think we are making an impression on Congress, and I suspect 20% and 40% will not be the final numbers," says Plotkin.

So what will the final number be? That depends on Congress.

VEHICLE FUEL ECONOMY PROPOSALS IN CONGRESS

Bill:						
S.279 [1]	S.341 [2]	S.741	HR.446	HR.550	HR.612	HR.1543 [3]
Main Sponsor:						
Sen. Richard Bryan (D-NV)	Sen. J. Bennett Johnston (D-LA)	Sen. Tim Wirth (D-CO)	Rep. Barbara Boxer (D-CA)	Rep. Leon Panetta (D-CA)	Rep. Dan Glickman (D-KS)	Rep. Norman Lent (R-NY)
Proposed Improvement Over 1988 CAFE, by MY 1996:						
Cars:						
20%	Max. Feas. Level	20%	20%	20%	25%	Max. Feas. Level
27.5 mpg City/40 Hwy	Set By DOT	27.5/40	27.5/45	27.5/40	27.5/–	Set By DOT
Light Trucks:						
20%	Max. Feas. Level	20%	20%	20%	25%	Max. Feas. Level
20 mpg City/30 Hwy	Set By DOT	20/30	20/35	20/30	20/–	Set By DOT
Proposed Improvement Over 1988 CAFE, by MY 2001:						
Cars:						
40%	Max. Feas. Level	40%	60%	40%	50%	Max. Feas. Level
33 mpg City/45 Hwy	Set By DOT	33/45	27.5/50	27.5/45	35/–	Set By DOT
Light Trucks:						
40%	Max. Feas. Level	40%	60%	40%	50%	Max. Feas. Level
24 mpg City/35 Hwy	Set By DOT	24/35	20/40	20/35	25/–	Set By DOT

[1]DOT secretary may increase or decrease standard based on 'maximum feasibility' test. Reduction may not exceed 5%, 1996-2000; 10%, 2001.
**Non-compliance fine is doubled if manufacturer falls short of standard for three consecutive years, by more than 0.05 mpg, beginning MY 1996.*
[2]Mileage credits earned by exceeding standards may be traded among vehicle manufacturers, for MY 1996.
**Small cars with driver's side airbags earn 5% fuel economy value; driver's/passenger's side airbags earn 10%.*
**DOE to provide aid to states to scrap pre-1980 vehicles.*
**Non-compliance fee replaces CAFE fine; raised to $20 per 0.1 mpg under MY 1996 standard. 1993 raised to $10.*
[3]Proposes DOT rule-making based on auto industry lead times and safety considerations. Proposes two-stage CAFE inprovements, the first to begin in the fourth MY after passage.

ON THE DOCKET

Even if the Bryan bill has been voted down by the time you read this, similar legislation is on the docket. At the time *Automotive Industries* went to press, there were seven fuel economy bills pending in the US Congress – three in the Senate and four in the House of Representatives, as the above chart shows.

'VAFE': ANOTHER ALTERNATIVE

Instead of CAFE, why not tailor fuel economy standards to the average interior volume of automakers' fleets – VAFE, or Volume Average Fuel Economy?

"You want to make a car as light as possible while maintaining safety, but you want an incentive for that weight reduction," the OTA's Steve Plotkin says. "So when you talk about size, you're looking for something which approximates utility. And interior volume, if it's measured properly, is not a bad measure of that."

Plotkin explains that VAFE could take two forms: It could be fuel economy standards tailored to EPA interior volume classes, or it could be based on a curve of fuel economy and interior volume.

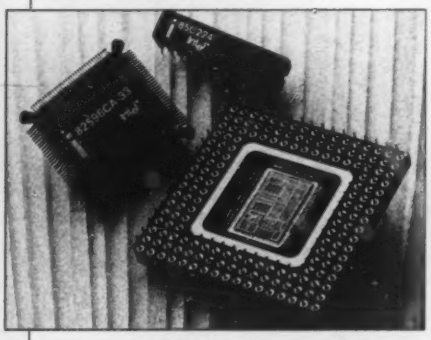
The VAFE proposal has yet to be incorporated into any legislation, and it's got a few political strikes against it already. "First, it's not as easy to explain as a uniform percentage increase like Bryan's, and there's no push in it for small cars," admits Plotkin. "Some senators really believe that one of the things we ought to be doing is getting people into small cars. VAFE has no incentive at all like that."

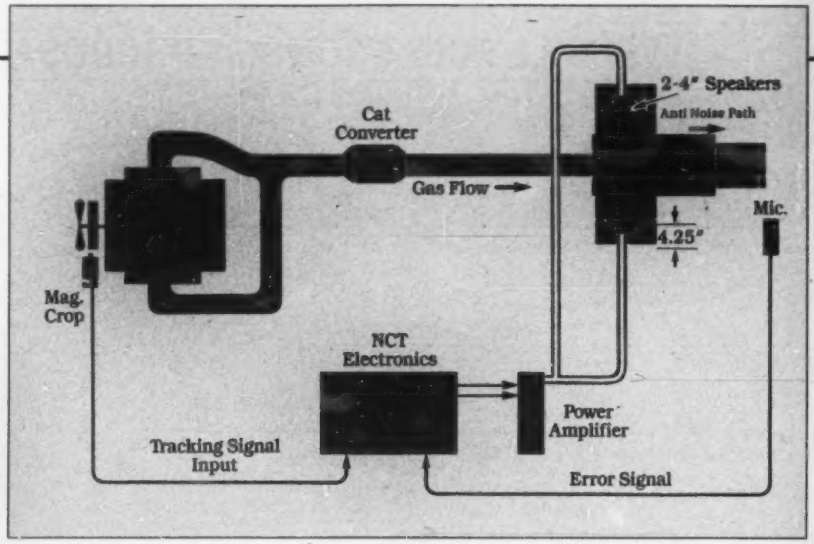
So the only format that will guarantee a minimum fleet fuel economy average is the current CAFE – "and that's the one nobody wants," he says.

Nevada's Richard Bryan (top) weighs the cost of 40-mpg CAFE with the cost of maintaining a military presence in the Middle East. Louisiana's J. Bennett Johnston's (bottom) bill is calling for a non-compliance fee that's four times stiffer than the current penalty for automakers.

40-MPG CAFE

32-bit micro's, like Intel's i486, will allow real-time powertrain control.





Electronic mufflers could improve fuel economy by 5%. Illustration: Walker/NCT

ON THE SHELF

A major challenge in meeting tighter CAFE standards is finding production-ready, on-the-shelf technology that offers a good return on investment. Since all 1995 models are already being developed, any legislation requiring massive fuel economy improvements by model year 1996 means that such technology must be available today.

We spoke with vehicle, powertrain and electronics engineers to determine what could be fitted to current projects. Certainly, there is a lot of new technology that will be coming in the next five years, and even more in the next decade. But these engineers claim there's nothing magic on the shelf which, by itself, will yield an instant 4 or 5 mpg. And they point out that any gains will be incremental, noting that you can't add up the incremental gains on a percentage basis to come up with the 20% or 40% required in legislation such as Sen. Bryan's.

Powertrain

So where will the auto industry concentrate its efforts? As might be expected, much of the push for more miles per gallon has focused on engine technology. According to Don Miles, a chief engineer at GM Powertrain, bumped-up compression ratios, to the 10:1 level and beyond, when used with freer-flowing ports, can improve combustion and fuel economy – if combined with higher octane fuel and remapped engine controllers.

And while many CAFE think-tankers sing the praises of multivalve cylinder heads, Miles points out they don't offer a 'free lunch.' While the multivalve engines offer improved combustion, they are compromised in other areas. Twice as many valves, guides, lifters and bearing surfaces can require up to 60% more oil flow for lubrication and cooling, which can multiply an engine's parasitic losses.

Additionally, with dohc there's often more engine weight – over 70 lbs. more when comparing some two-valve and four-valve V6s. More powertrain weight requires beefier cradles and heavier suspension pieces. To help cut weight, thinner-wall engine castings and more aluminum and plastics are coming.

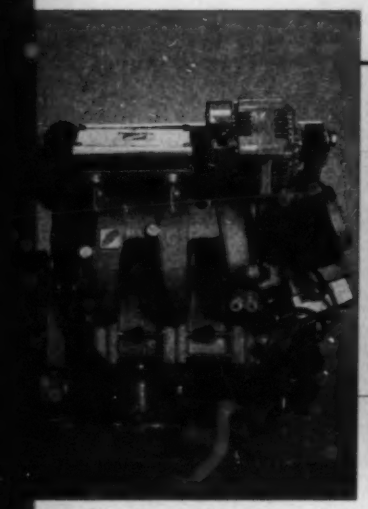
As an alternative to gasoline-powered engines, some powertrain engineers predict a return of the small-to-medium displacement turbodiesel. These engines are currently popular in Europe and would probably have to be purchased by the Big Three.

Of new piston engines on the near horizon, the most promising in terms of fuel efficiency is the two-stroke. Australia's Orbital Engine Co. is leading the pack here, with GM, Ford and Fiat as major automotive licensees. Orbital's 1.2 L three-cylinder, direct-injection, 90-hp two-stroke is half the physical size and weight of a typical 1.6 L sohc four-stroke four-cylinder. It gives about 12% better actual engine fuel economy than a 1.4 L sohc four installed in the same test car. And it has the potential to offer up to 30% better overall fuel efficiency, if installed in a car that's designed for it. Orbital officials reckon the engine's first US automotive use by their licensees will be bolted into an existing platform.

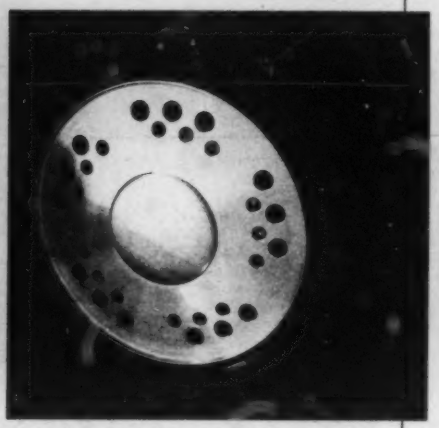
Improvements in transmissions will also play an important role. Higher gear ratios, taller final drive ratios, six- and seven-speed manual gearboxes and five- and six-speed automatics are all being considered. But they will require engines with fatter torque curves and lighter weight vehicles to maintain decent launch and roll-on acceleration. And adding cogs to existing gearsets means larger and heavier transmission cases – again, there's no free lunch. Other near-term fuel-saving technology includes de-clutching mechanisms and continuously-variable transmissions. CVTs are still torque-limited, however, and face durability questions when mated with engines larger than about 1.3 L.

Electronics

Of course, improvements in the powertrain aren't limited to hardware. Programming changes with on-board electronics could be accomplished fairly quickly, say experts in the electronics industry. By sacrificing performance, for example, engines could be electronically tuned to squeeze out the last drop of fuel efficiency. Some



Orbital's new 90 hp, three-cylinder, 1.2 L two-stroke (above left) will enter production soon. GM's highly-refined 3.3 L and 3.8 L V6s (above right) will add thin-wall iron block/head castings for less mass, roller rocker arms for less friction.



Tires designed to run at 50-65 psi, such as those fitted to GM's Impact electric car, drastically improve roll resistance.

experts also suggest that an 'electronic governor' limiting acceleration could be easily programmed into the engine microprocessor. Since it's merely a new algorithm, there would be no additional hardware cost.

More powerful microprocessors could also enhance fuel economy. Currently the most powerful micros are 16-bit machines. But GM will have a 32-bit machine in certain 1993 models and Ford will follow in 1997.

These powerful micros allow engineers to 'computer model' the combustion process. This refers to monitoring and controlling engine parameters such as valve and spark timing on a real-time basis. And by connecting engine controllers to electronic transmissions, they'll be able to select optimum shift points for better fuel economy.

With additional computing power, cruise controls could hold a car at its most fuel-efficient speed based on the load being carried in the car. But it would also take about $50 worth of sensors, such as a load level sensor, engine load sensor, to accomplish this.

If given more time, experts in the electronics industry say they have a few more tricks up their sleeves to boost fuel economy. Of special interest is the 'electronic muffler,' which uses DSP (digital signalling processing) chips to create sound waves that are equal and opposite to the sound waves coming out the exhaust pipe. This allows baffles to be removed from the muffler, reducing back pressure and weight.

According to muffler supplier Walker Manufacturing, this reduction in back pressure improves city fuel economy by 5% on a V8 powered car. However, noise cancellation systems could cost as much as $500.

Other electronic technology includes multiplexing that could improve diagnostic capabilities, but would add about $400 to the cost of a car. And fiber optics have the potential to replace long runs of wire. "It's estimated that in a typical car approximately one mile of wiring can be eliminated," says George English, director of lighting systems development for GTE Electrical Products.

Lightweight Materials

Virtually every automaker has looked at making cars using more exotic lightweight materials – at least more exotic than steel or plastic. But again, this approach won't be available in the short term. Ford has probably taken the boldest step with its Contour Project (see *AI* March '91, p. 24). According to Ford, Contour's aluminum spaceframe design would shave several hundred pounds off the weight of an all-steel body-in-white, while being very cost effective because it is extruded and bonded. However, the bonding process has yet to be proven for mass production.

Alternatives to aluminum include graphite or Kevlar/epoxy, which have been studied most extensively at GM. Kevlar/epoxy yields a spaceframe that gives repeatable and satisfactory crash results while using cost-effective materials. Weight savings of 150 lbs. could be realized over steel. The problem with K/E is that use of filament winding techniques or resin transfer molding is far too slow for mass production. Graphite has high strength and low weight but at an unacceptable cost, and is unpredictable in terms of repeatable crash results.

Components

Automakers are also looking at bolt-on componentry that could enhance fuel economy. For example, continuous tire 'tuning' – optimizing aspect ratios, adding new polymer technologies and designing for higher pressures – is sure to yield more miles per gallon along with better performance. A good example of this technology is the high-pressure Goodyear tire – designed for 50-65-psi – that's fitted to GM's Impact electric car prototype.

Bill Egan, Goodyear's chief engineer for advanced OE equipment technology, says tradeoffs of higher pressures include increased ride harshness and tread wear. "We've got to be able to keep a good 'footprint' geometry; that's a key to good tire performance," he notes. "We're working on that now."

Even a vehicle's cooling system offers the potential to reduce fuel consumption. Siemens is presently testing

40-MPG CAFE

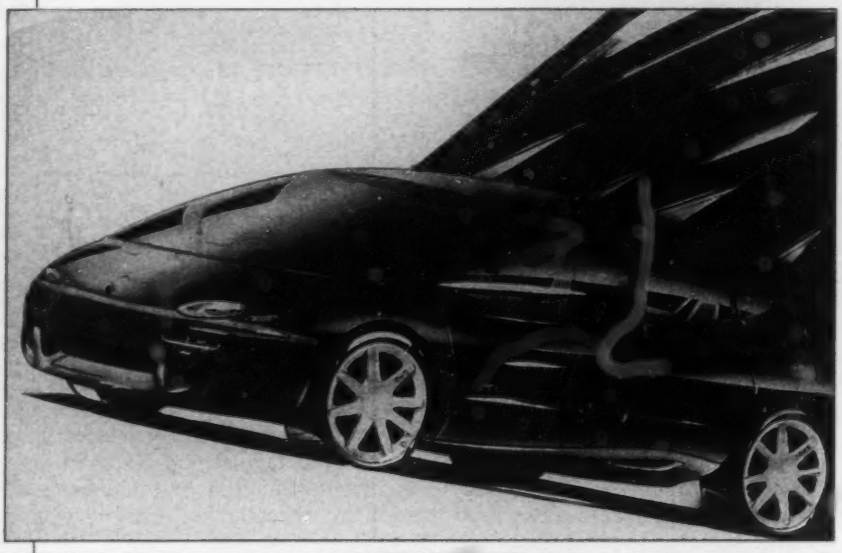
a ducted cooling system on a Mercury Sable that is designed to decrease underhood temperatures and lessen hot fuel handling problems. By lowering lower underhood temperatures, the fuel supply going to the engine can be made cooler. Colder fuel means a denser charge, more efficiency, and the chance to run the engine closer to the edge on performance.

In addition, with such a cooling system, air intakes can be optimized for greater aerodynamic efficiency. And Ford hopes that by ducting air from the cooling system into the front wheelwells it can 'trick' the airflow into 'seeing' a smaller frontal area by breaking the vortexes created by the wheels.

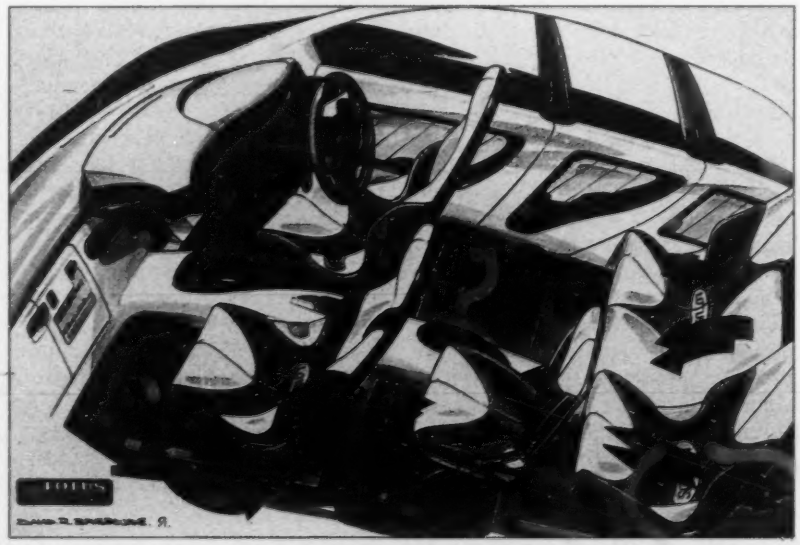
Other aerodynamic tricks could include an adjustable ride height – raking the nose down and raising the tail – to reduce aerodynamic drag by 3% to 5%. But it cannot be used to its full advantage due to government regulations for uniform bumper height. However, United Technologies Automotive has unveiled research which shows that 'vortex generators' offer a 30% Cd reduction in bluff body (square box) wind tunnel tests.

The vortex generators are simply sinusoidal waves – which look like corrugated curves – molded into the trailing edge of a decklid or spoiler. They cause the air coming off the rear of a car to spiral, mixing high pressure into low pressure areas to reduce turbulence. Moreover, they could be used in catalytic converters and mufflers to improve flow and reduce noise, or even integrated into a radiator to improve airflow there.

The list goes on and on. But as noted, none of this technology is expected to yield the massive fuel economy improvements Congress expects – at least not while maintaining today's levels of safety or performance. But if given more time, outside of today's cycle plans, the auto industry has some fairly clever ideas on the drawing board.



From Lotus: 60 mpg with 0-100 km/h in 6 seconds from a 1.2 L engine. Illustration: David R. Brisbourne, Lotus Design



Flexible interior gives mobile office, cargo and seven-passenger capability. Illustration: David R. Brisbourne, Lotus Design

ON THE DRAWING BOARD

High fuel economy, and high performance, are not mutually exclusive items, says Lotus Engineering. Indeed, as per a request by *Automotive Industries*, Lotus has brainstormed a concept vehicle that would seem to satisfy Senator Bryan, the auto industry, mom and even Ayrton Senna. Basically, Lotus has designed a seven-passenger vehicle, powered by a 1.2 L engine that would deliver 60 mpg and achieve 0-100 km/h times in six seconds!

Ken Sears, Chief Engineer, Vehicle Concepts at Lotus Engineering explains:

"The technology expected to appear in the next five to 10 years will be the basis for vehicles in the year 2010, so the future is not far away. And buyers will demand improved performance, durability, and safety – all with higher equipment and refinement levels. Thus the materials industry must make commercially available recyclable materials with properties significantly beyond today's norms.

"Because the size and number of occupants and highways will be much the same as today, vehicle size can't change radically. Optimized packaging will allow occupant and luggage space within a shorter overall length, more vehicles per mile of highway, fewer

parking problems, better passenger comfort and crash protection—without greatly increasing frontal area and aerodynamic drag.

"The vehicle pictured is powered by a 1.2 L four-stroke, four valve/cylinder piston engine producing 134 hp [100 kW] and 150 lb/ft of torque. High-pressure charged induction [supercharging], direct fuel injection, and computer-controlled individual valve actuation [there are no camshafts] will ensure very high efficiency, and more than 100 hp/L—but with vastly improved fuel economy and exhaust emissions. Aluminum is used for major casings, plastics for smaller parts, high-performance alloy steel for stressed components, and ceramic composites for the most arduous heat and stress areas.

"The engine is coupled to a high efficiency CVT. An electronic powertrain management system controls engine operating speed and load, valve lift and timing, induction pressure, fuel injection—and the transmission—to optimize efficiency at all power demands. Our simulations confirm expected huge improvements in performance and economy through reduced systems inefficiency and optimized powertrain control.

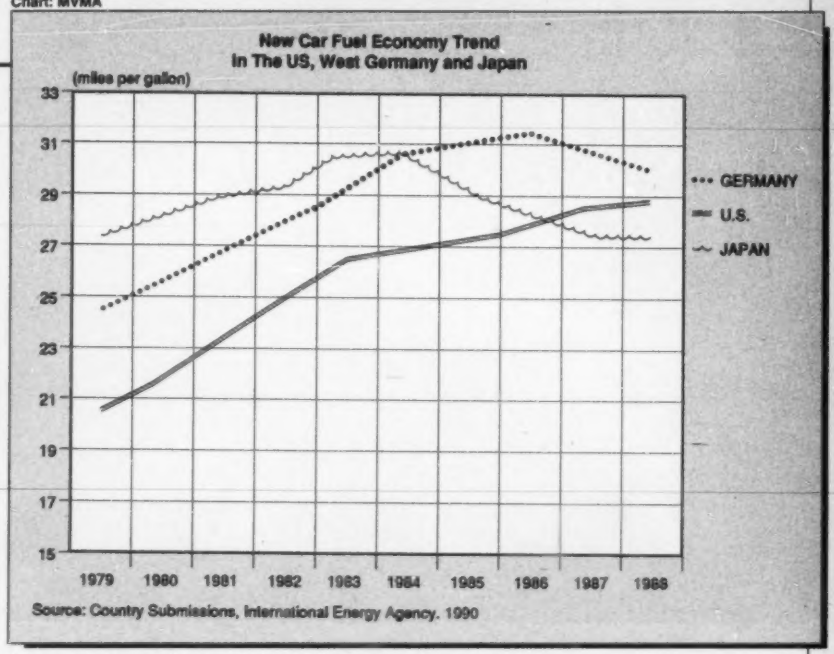
"Comfort, control and safety are enhanced by the active suspension system which is tied into the powertrain computer. This helps reduce its power consumption. A noise cancellation exhaust is also featured.

"The 2206 lb [1000 kg] vehicle sits on a 102 in. wheelbase. Overall length is 174 in. which offers seven passenger capacity. The front passenger seat can face rearward, and the rear seats slide fore and aft. The middle seats can be folded into the floor, and by removing the rear seats and part of the center console creates a flat load space."

CONCLUSION

Can the automotive industry achieve a 40% improvement in CAFE standards? You bet. But cars would become smaller, slower and much, much more expensive than they are today. And when given the choice, consumers have overwhelmingly opted for comfort, convenience and performance—not fuel economy.

Chart: MVMA



Higher gas taxes? It hasn't helped CAFE much in Europe and Japan.

So maybe Congress is going about it the wrong way. But the auto industry has certainly left a vacuum for Congress to fill. As far as the public is concerned, the industry creates the impression that it is dead set against doing anything. And yet, the auto industry has a positive story to tell. But to wrest the initiative away from Congress it must be proactive, not reactive. It must show the nation that it too has a plan to reduce the nation's dependence on oil.

First of all, we think the industry could push for faster development of Intelligent Vehicle Highway Systems (IVHS). These interactive 'smart' roads, now being tested in 22 states and 26 cities, can 'read' traffic densities and greatly improve traffic flow. Indeed, a recent CalTrans study of traffic congestion stated that if congestion causes rush hour traffic speeds to drop from 30 mph to 10 mph, fuel consumption increases 100%, with large increases in exhaust emissions.

Second, anything that could be done to get pre-1983 vehicles off the road—those with the worst fuel economy and exhaust emissions—would have the greatest short-term effect. Perhaps this could be done through one-time tax breaks, or sales incentives. Obviously, mandating their removal wouldn't be feasible, as it would hit poor people the hardest. But it would reduce US gasoline consumption in a hurry.

Third, accelerating electric and alternative-fueled vehicle development and production, would reduce US consumption of imported oil. But until alternate fuels are available at the corner gas station, all the talk about these fuels is just that—talk.

Fourth, calls for higher gasoline taxes should be dismissed outright. Though gasoline in Europe and Japan costs three to four times as much as it does in the US, their CAFE levels are not much higher (see accompanying graph).

Lastly, Congress must take responsibility for legislating regulations with a common sense approach. All too often automakers are forced to comply with regulations that work against each other. For example, tighter emission standards adversely affect fuel economy. And safety legislation usually requires additional equipment that adds weight, which causes fuel economy to decrease. Obviously, improvements in emissions, fuel economy and safety are areas best left to the regulatory process—not market competition.

But unless the auto industry gets out ahead of the issues and helps to set the debate, it can look forward to a future where 'Bryan bills' are the norm, not the exception. AJ